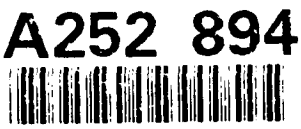

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CHEMICAL
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CRDEC-TR-348

A NEW AND NOVEL METHOD FOR MASK LEAK DETECTION

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The protection factor provided for tobacco smoke was compared to the protection factors of isoamylacetate (banana oil) using 80 human volunteers. The findings show that, in general, people are more sensitive to tobacco odor than banana oil odor; that Blacks are more sensitive to tobacco odor than Whites; and that females are more sensitive to banana oil odor than males.

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PREFACE

The work described in this report was authorized under Project No. 1C162622A553D, Individual Protection. This work was started in May 1988 and completed in August 1988.

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A NEW AND NOVEL METHOD FOR MASK LEAK DETECTION

1. INTRODUCTION

In the field, the current method for testing the integrity of the respirator face mask is a two stage process.[1] After masking, the soldier performs the "negative pressure test" by covering the filter canister with his hand and inhaling deeply. If the mask stays collapsed, a good seal is assumed. If time permits, the second stage is performed. This test is an olfactory test using isoamyl acetate (also known as banana oil due to its characteristic odor) as a challenge material. The test is conducted by passing a cotton swab that had been dipped in banana oil around the periphery of the mask. A good fit is indicated by the lack of odor. Although no detailed information is available on the degree of protection that the use of banana oil provides, investigators generally believe that the human olfactory sensitivity to this material is sufficient to provide protection against the "classical" chemical warfare agents.

Tobacco smoke presents a good candidate challenge material for a field expedient mask integrity test. This material is easily available to the soldier, does not need to be maintained, and its use requires minimal or no training. Thus, obtaining the material does not add to the already overburdened logistics system.

Previously, we discussed the possibility of using tobacco odor to supplement banana oil for mask leakage testing, and we speculated that increased protection could be achieved by the former.[2] In this report, we discuss the results of tests recently conducted at U.S. Army Chemical Research, Development and Engineering Center (CRDEC) that compare the use of cigarette smoke to banana oil for detection of leaks in the respiratory face mask.

2. TEST DESCRIPTION

Human volunteers wearing a protective mask (either M40 or M17) were exposed to either cigarette smoke or banana oil, and their responses were recorded. The volunteers were requested to fill in a questionnaire, which provided personal data such as sex, race, age, and personal habits (e.g., smoking). A sample questionnaire is attached as the appendix. The test was conducted in the following manner:

- The subject was fitted with a mask and was told that he/she would be exposed to three challenges of which at least one would be clean air and the others would be either tobacco smoke, banana oil, or clean air.

- The subject was blindfolded by covering the mask's lenses with face plate covers.

- The subject was presented with the three challenge materials separately and in a random sequence. During each presentation, the subject was asked to perform five standard exercises (i.e., normal breathing, deep breathing, turning head side to side, moving head up and down, and reciting the alphabet). Cigarette smoke was presented to the subject by moving a lit cigarette around the periphery of the mask, making sure the cigarette was far enough from the subject's face to preclude heat sensation. The banana oil was presented by dipping a "dip stick" with a cotton swab in banana oil and moving the dip stick around the periphery of the mask. "Air" was presented by moving a clean dip stick around the periphery of the mask.

- During each presentation of challenge material, the subject was asked whether he/she could smell anything. If the answer was positive, he/she was asked to identify the odor (i.e., banana oil or tobacco smoke) and to rank its intensity as light, medium, or strong.

- Following the three odor tests, the lens face plate covers were removed, and the subject walked to the next room to perform the "protective factor" (PF) test, using corn oil aerosol.

- The subject removed his/her mask and returned to the rest station to wait for the next test. Subsequent tests on the same subject were spaced by at least 30-min intervals.

Before the test started, a list of 500 random presentations of banana oil, cigarette smoke, and air was prepared. During the test, the odorants were presented in the order indicated by that list.

3. RESULTS AND DISCUSSION

Eighty persons performed 460 tests. Each test consisted of presenting three challenge materials, as discussed above. The test subjects included 10 females, 70 males, 25 smokers, and 55 nonsmokers (approximately 1/3 of each group were smokers). The racial mix included 46 Whites, 19 Blacks, 10 Hispanics, and 5 Asians. The volunteers were civilian and military personnel employed at the Edgewood Area of Aberdeen Proving Ground. The vast majority of the test subjects were young military personnel between late teens and early twenties. Those who smoked reported that they smoke between one and two packs per day. None of the volunteers reported significant allergies.

During the planning of the study, several people expressed concern that smokers would not be able to detect cigarette smoke as well as nonsmokers and that this would be disadvantageous since a large number of troops smoke during periods of hostility. Several researchers have investigated the affect of smoking on olfactory sensitivity. Ahlstrom and co-workers report that smokers have a keener sense to low concentrations of pyridin than nonsmokers.[3,4] However, their responses to higher concentrations are similar to the responses of nonsmokers. Furth[5] reports that habitual smokers showed reduced sensitivity to guaiacol. Moncrieff[6] reports that smoking did not influence the olfactory sensitivity to ethyl mercaptan, butyric acid, and triethylamine but raised the threshold for pyridin. Gilbert and co-workers[7] report that smoking affects the olfactory perception but that smokers generally perceive banana oil as more intense than nonsmokers.

Figure 1 shows the percentage of tests in which the subject correctly identified the odorant presented to them. The first set of bars represents tests in which the PF was less than 1000; whereas, the second set of bars represents data with the PF >1000. The last set represents the data from all levels of PF. The numbers above the bars give the total number of tests. The number above each set gives the level of significance (LS) for the difference between the two groups represented by the bars. As can be seen, tobacco odor was detected approximately 25-30% more frequently than banana oil at an equivalent PF. This difference is highly significant at the 99.5% level for the lower PF and 90% significant for the higher PF. The confidence level was estimated by calculating the Chi-square for 2 by 2 contingency table.[8] Note that the Yates' Correction suggested by Spiegel for discrete data was shown to degrade the approximation to the Chi-square distribution[9] and was not used. It should be noted that if the subject was to guess the odor, he would be correct in 33% of the cases.

Figures 2 and 3 show the fraction of tests in which the smokers and nonsmokers recognized the material that was presented to them. As can be seen among smokers, the ratio between those who smelled cigarette smoke to those who smelled banana oil is about 2:1; whereas, among nonsmokers, the difference is much smaller; and at high PF (>1000), there is no significant difference between them. This indicates smokers' diminished sensitivity to banana oil but not to cigarette smoke. This is further illustrated in Figures 4 and 5, which show that although a significantly larger fraction of nonsmokers can detect banana oil than smokers, the difference between the two groups in their sensitivity to cigarette smoke is insignificant.

A large fraction of the military are noncaucasians, primarily blacks, and the number of females is increasing. Gilbert and co-workers[7] report that the olfactory perception of

different odorants varied across the globe. However, no details are provided in their preliminary report. Figures 6 and 7 compare the fraction of Black and White test subjects who were able to detect banana oil versus cigarette smoke. As can be seen, about 60-70% more Blacks could detect cigarette smoke than could detect banana oil. The ratio for Whites is significantly smaller. Interestingly, the difference is due to Blacks' greater olfactory sensitivity to cigarette smoke as shown in Figures 8 and 9.

Females were the only group that did not gain protection from using cigarette smoke instead of banana oil. (The fraction of males and females able to recognize the challenge material presented to them is shown in Figures 10 and 11). The reason is that females are more sensitive than males to banana oil as shown in Figure 12. This agrees with the finding of Gilbert and co-workers[7] who report that women, in general, are more sensitive to different odorants than men. The sensitivity of males and females to cigarette smoke, however, is comparable. The data in Figure 13 shows that females would not lose protection by changing to cigarette smoke for leak testing.

4. CONCLUSIONS

The data presented in this report show, unequivocally, that tests with cigarette smoke can provide a better protection factor than banana oil as a challenge material for mask integrity tests under field conditions. Furthermore, not only can cigarette smoke be detected by more people than banana oil at a given protection factor, but this odorant can be detected by similar fraction by the different groups that participated in the test (except that Blacks are more sensitive to cigarette smoke than other groups); whereas, larger differences exist in the ability of the different groups to detect banana oil (Figures 14 and 15). Even though no statistically reliable data were obtained on other racial groups (i.e., Asian Pacific, Hispanic, and Native American), the test group probably represents the majority of personnel in the armed services with regard to age, sex, race, and other factors relevant to the abilities in question.

5. RECOMMENDATIONS

We recommend that serious consideration be given to adopt the mask fitness test using cigarette smoke and to bring to the attention of the U.S. Army Chemical School and, ultimately, the troops, that this alternate challenge material can supplement and even replace banana oil in mask leak testing in the field. To this end, a standing operating procedure (SOP) should be prepared and incorporated into the field manual.

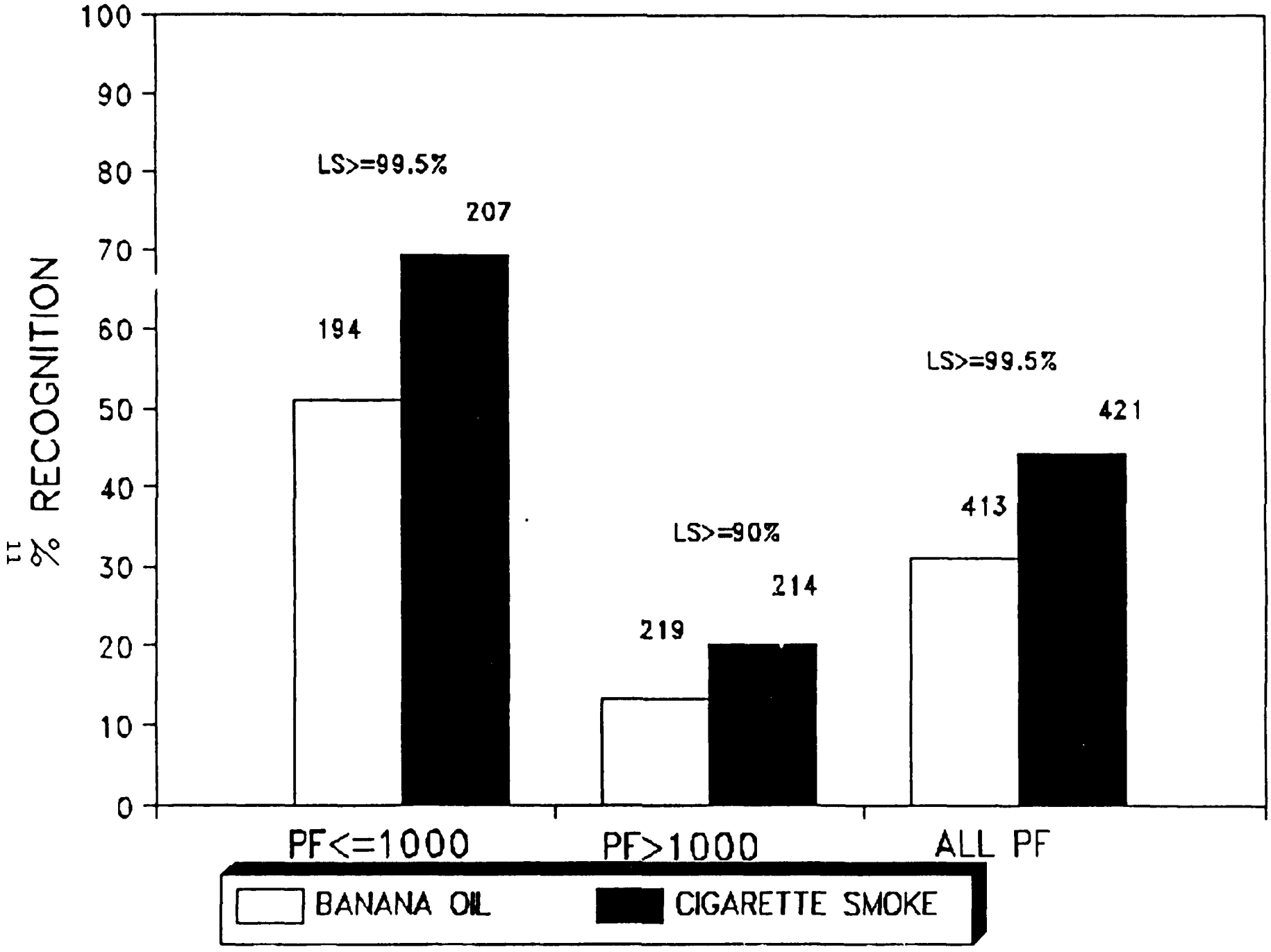

Figure 1. Odor Recognition of Banana Oil Versus Cigarette Smoke. All Test Subjects.

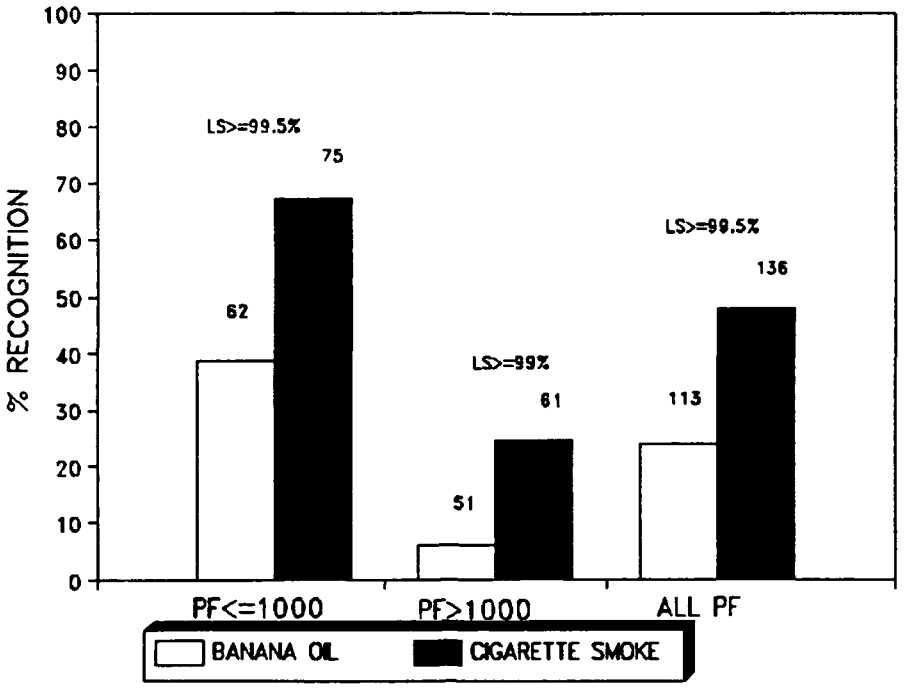

Figure 2. Odor Recognition of Banana Oil Versus Cigarette Smoke. Smokers.

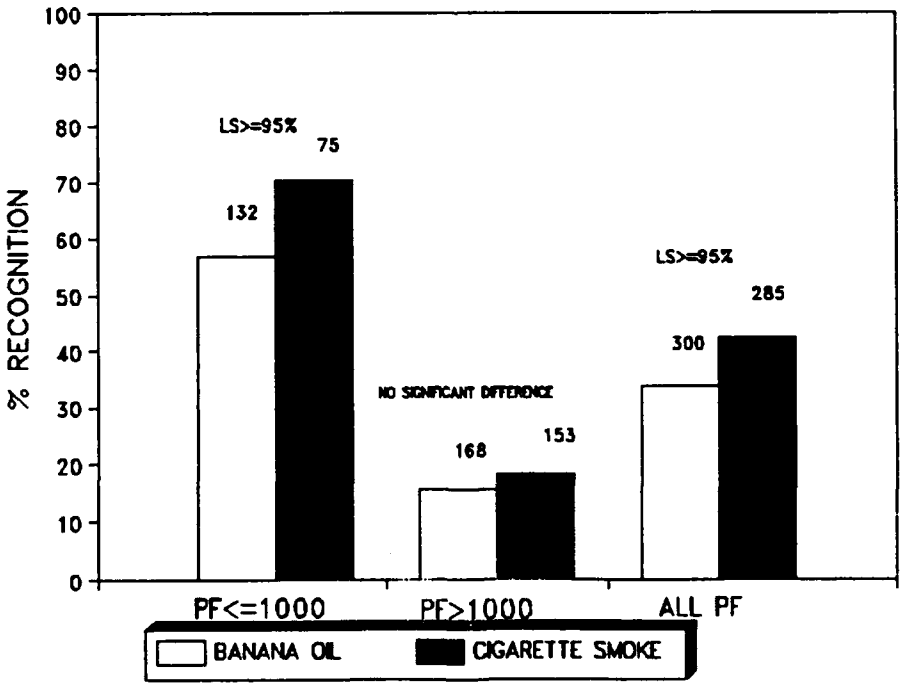

Figure 3. Odor Recognition of Banana Oil Versus Cigarette Smoke. Nonsmokers.

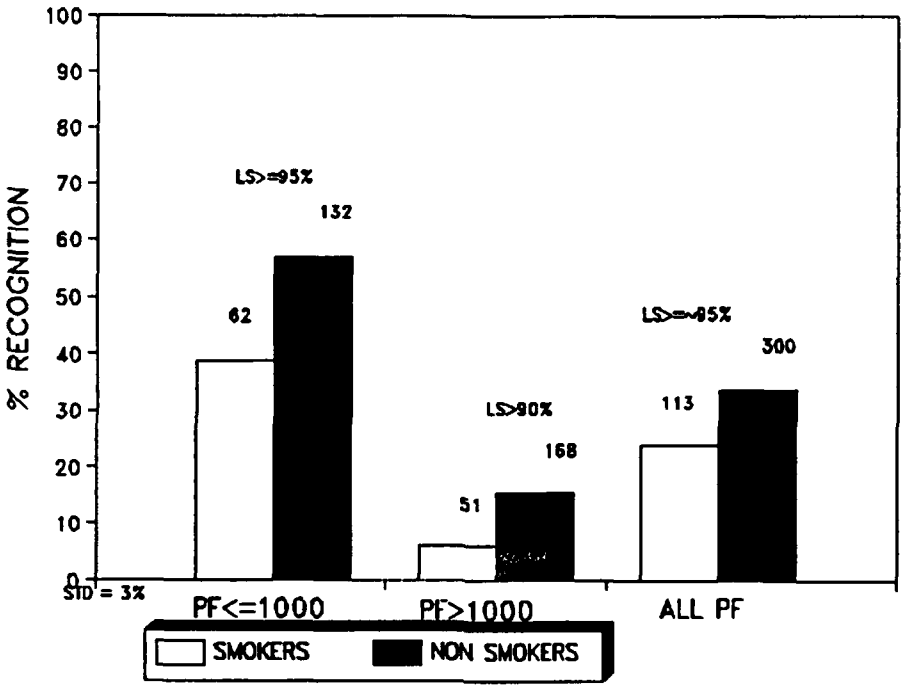

Figure 4. Comparison of Sensitivity of Smokers and Nonsmokers to Banana Oil.

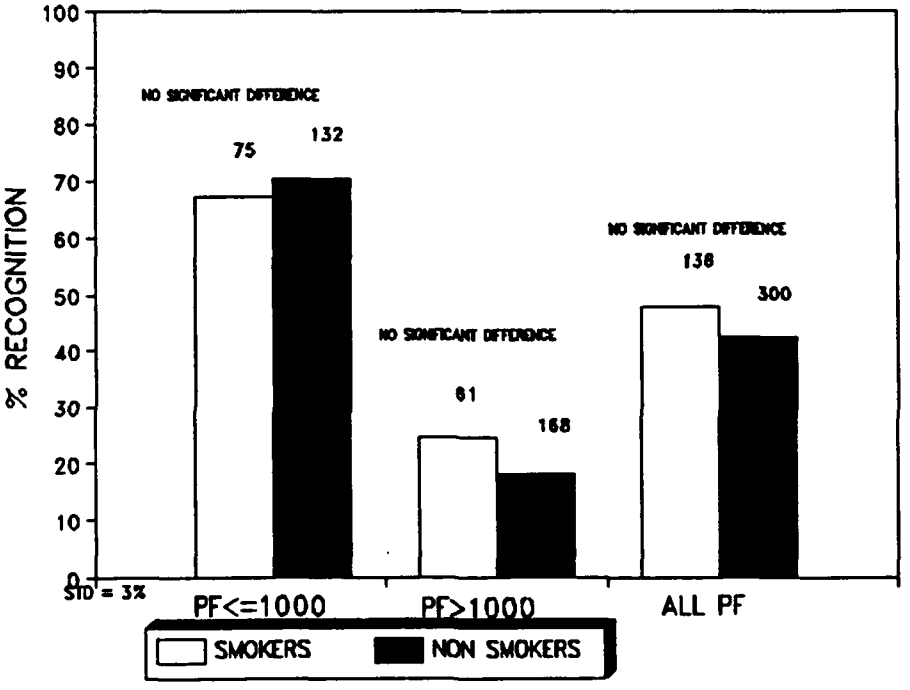

Figure 5. Comparison of Sensitivity of Smokers and Nonsmokers to Cigarette Smoke.

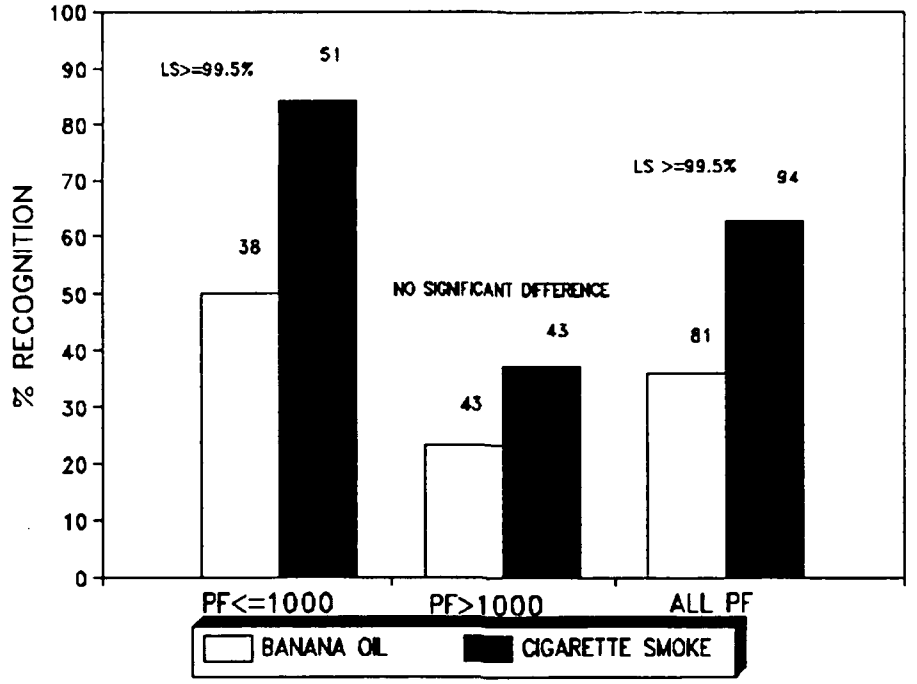

Figure 6. Odor Recognition of Banana Oil Versus Cigarette Smoke. Blacks.

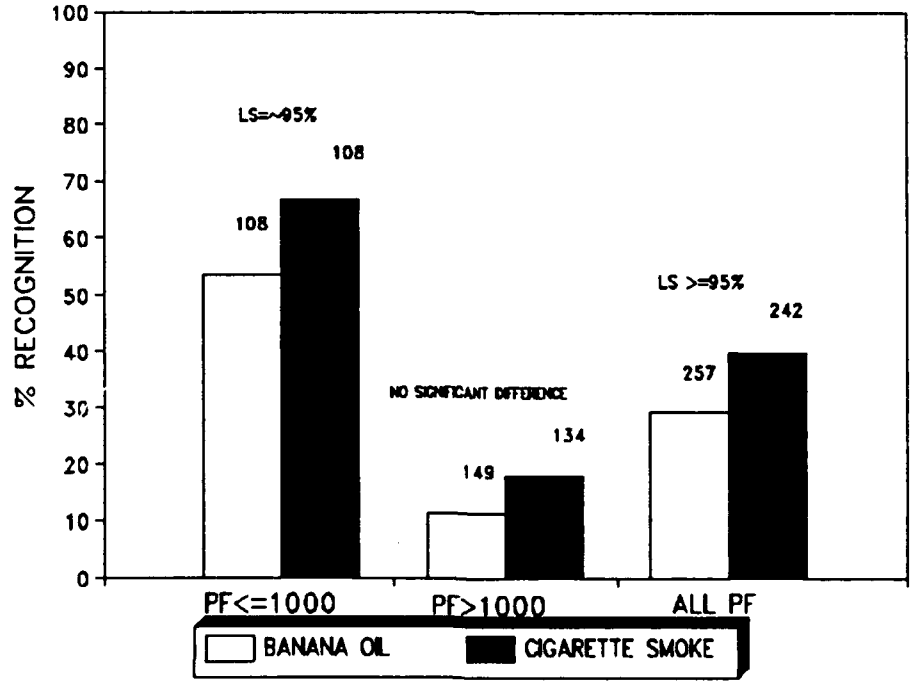

Figure 7. Odor Recognition of Banana Oil Versus Cigarette Smoke. Whites.

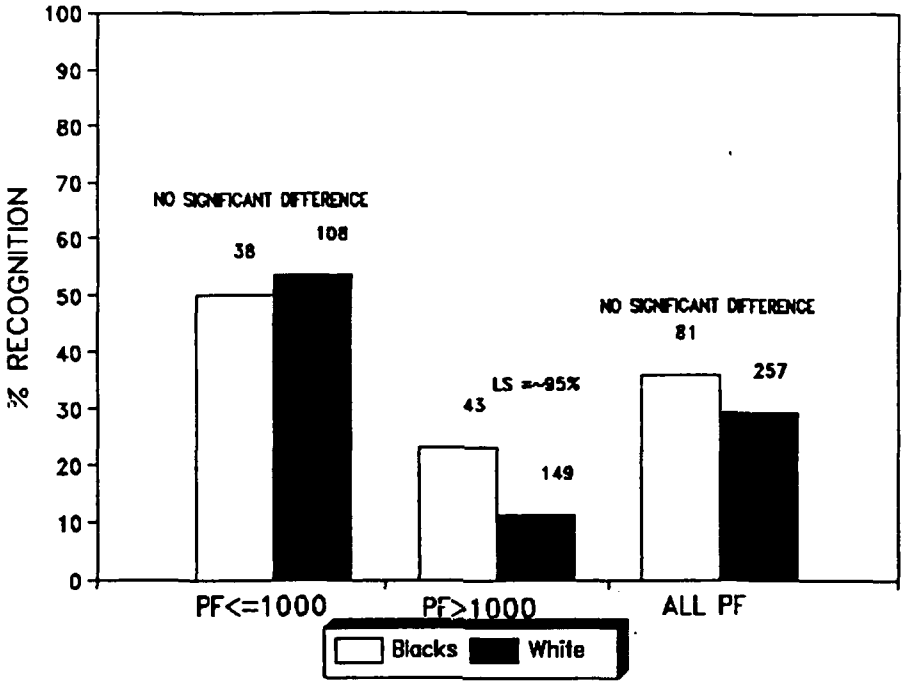

Figure 8. Comparison of Sensitivity of Whites Versus Blacks to Banana Oil.

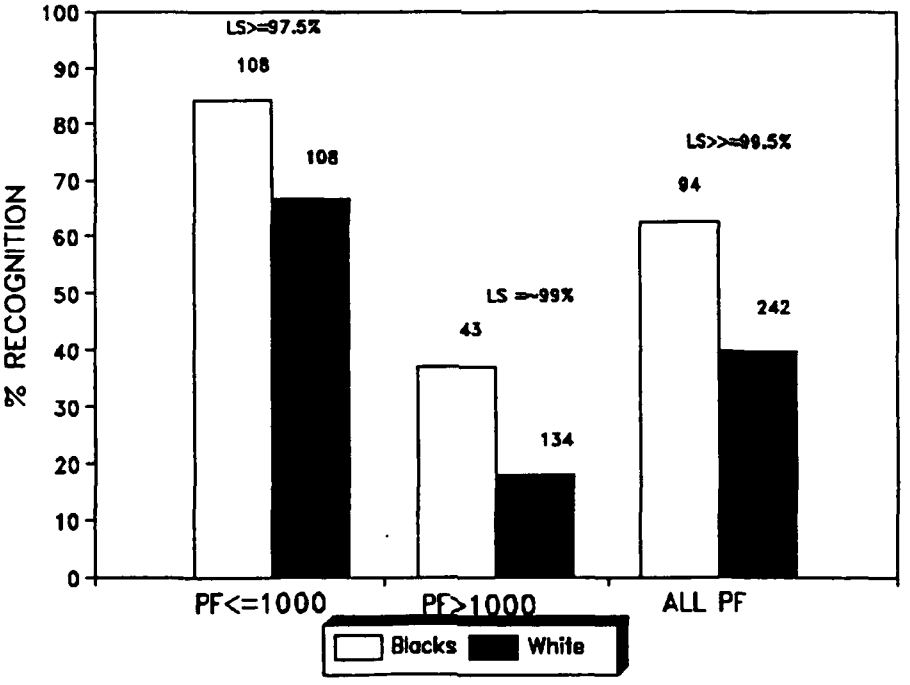

Figure 9. Comparison of Sensitivity of Whites Versus Blacks to Cigarette Smoke.

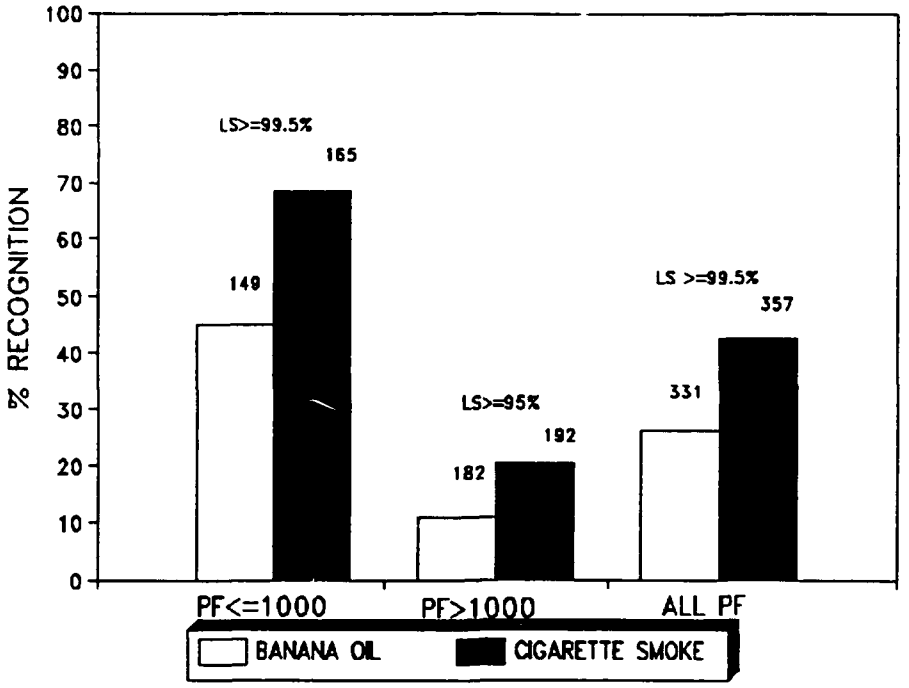

Figure 10. Odor Recognition of Banana Oil Versus Cigarette Smoke. Males.

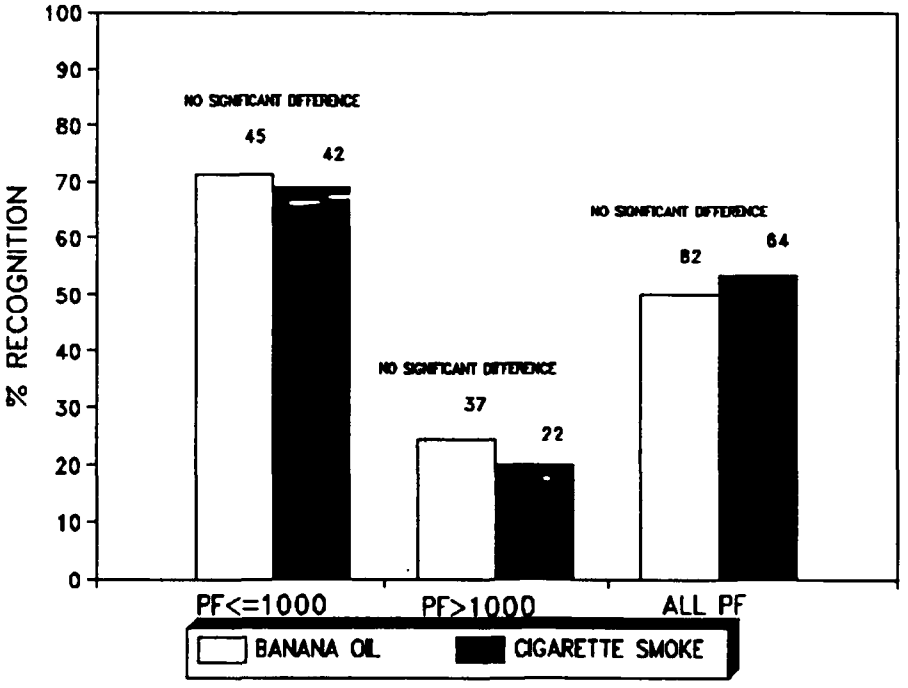

Figure 11. Odor Recognition of Banana Oil Versus Cigarette Smoke. Females.

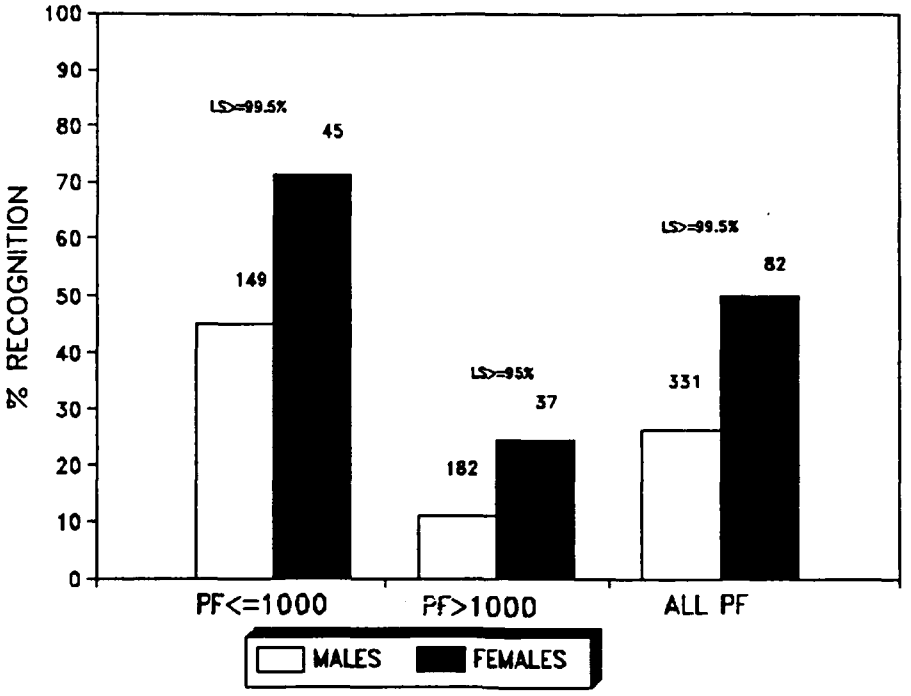

Figure 12. Comparison of Sensitivity of Males Versus Females to Banana Oil.

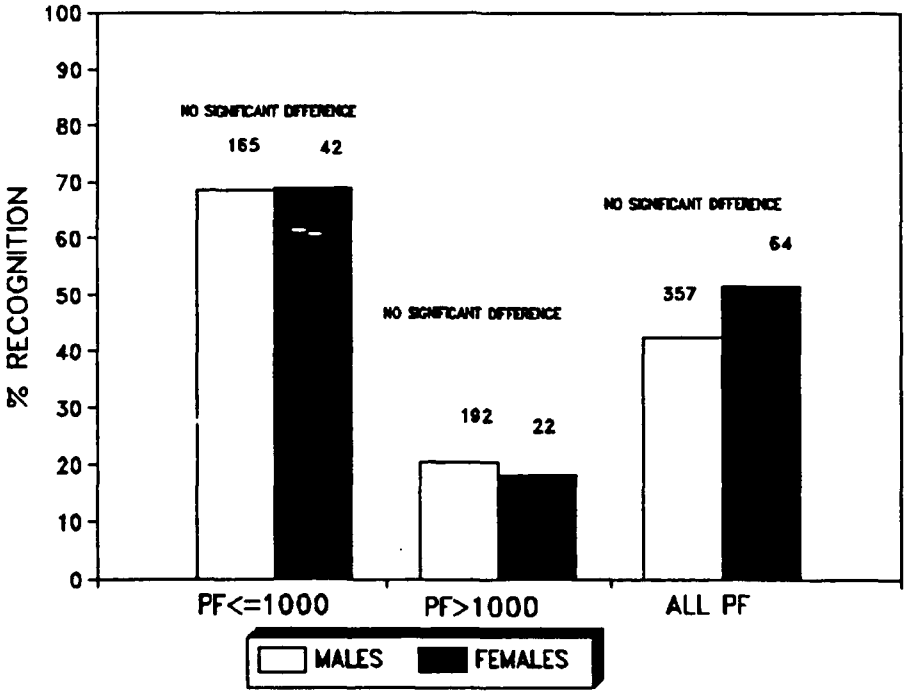

Figure 13. Comparison of Sensitivity of Males Versus Females to Cigarette Smoke.

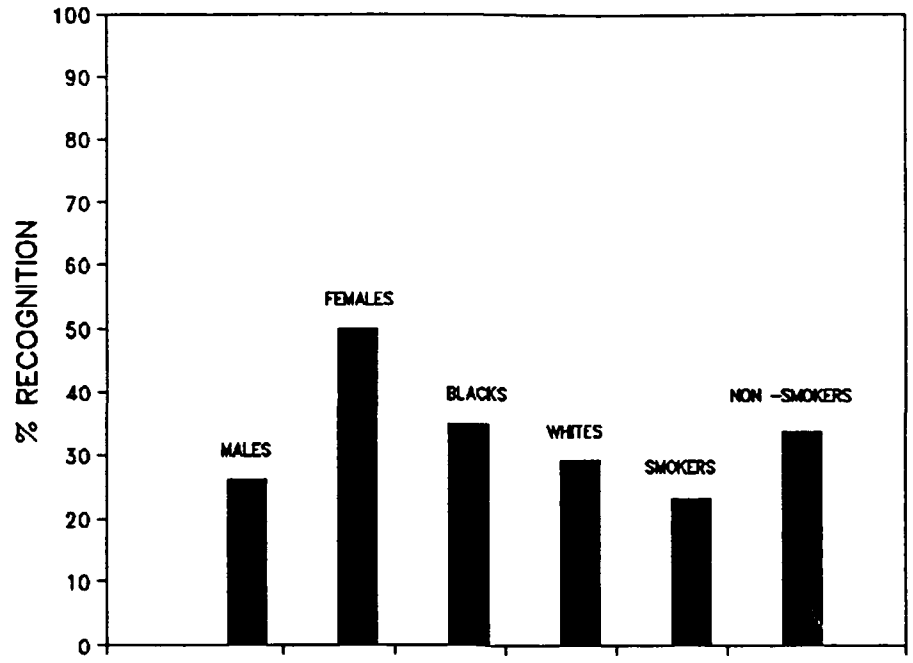

Figure 14. Comparison of Sensitivity of Different Groups to Banana Oil.

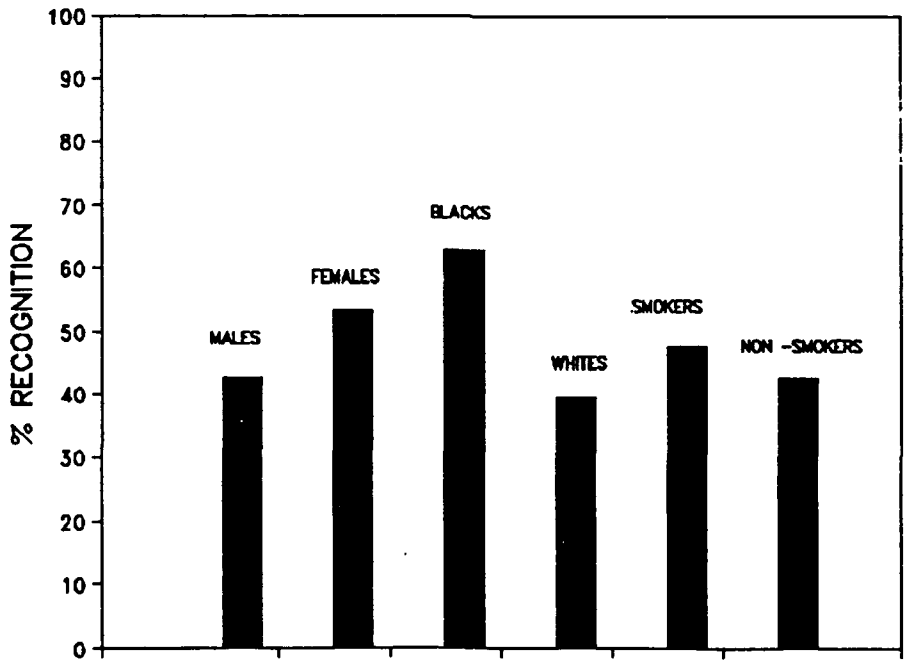

Figure 15. Comparison of Sensitivity of Different Groups to Cigarette Smoke.

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APPENDIX

Background Questionnaire

Human Use Protocol for a Feasibility Study to Develop a Field Expedient Mask Integrity Test Using Tobacco Odor

MASK FITNESS TEST

BACKGROUND SURVEY QUESTIONNAIRE

1. NAME:_____
   Last First MI

2. SOCIAL SECURITY NUMBER:_____-____-_____

3. AGE:_____

4. SEX: M____ F_____

5. RACE:

   American Indian or Alaskan Native_____

   Asian or Pacific Islander_____

   Black_____

   White_____

   Hispanic Origin_____

   Other_____(specify)

6. Smoker? Yes _____ No _____

   IF YOU ARE A NONSMOKER, THEN SKIP TO QUESTION 9.

7. How much do you smoke regularly?

   Less than one pack (20 cigarettes)/day? _____

   Between one and two packs/day? _____

   Between two and three packs/day? _____

   More than three packs/day? _____

8. When did you smoke your last cigarette?

Within the last 5 minutes? _____

Within the last 30 minutes? _____

Within the last 1 hour? _____

Within the last 2 hours? _____

More than 2 hours ago?

9. If you are not a smoker now, did you smoke in the past?

Yes _____ No _____

IF NOT SKIP TO QUESTION 11

10. When did you stop smoking?

Within the last month? _____

Within the last 6 months? _____

Within the last year? _____

More than a year ago? _____

11. Do you have a cold? Yes _____ No _____

12. Do you have a headache? Yes _____ No _____

13. Do you have an allergy?

IF YES, PLEASE SPECIFY: _____